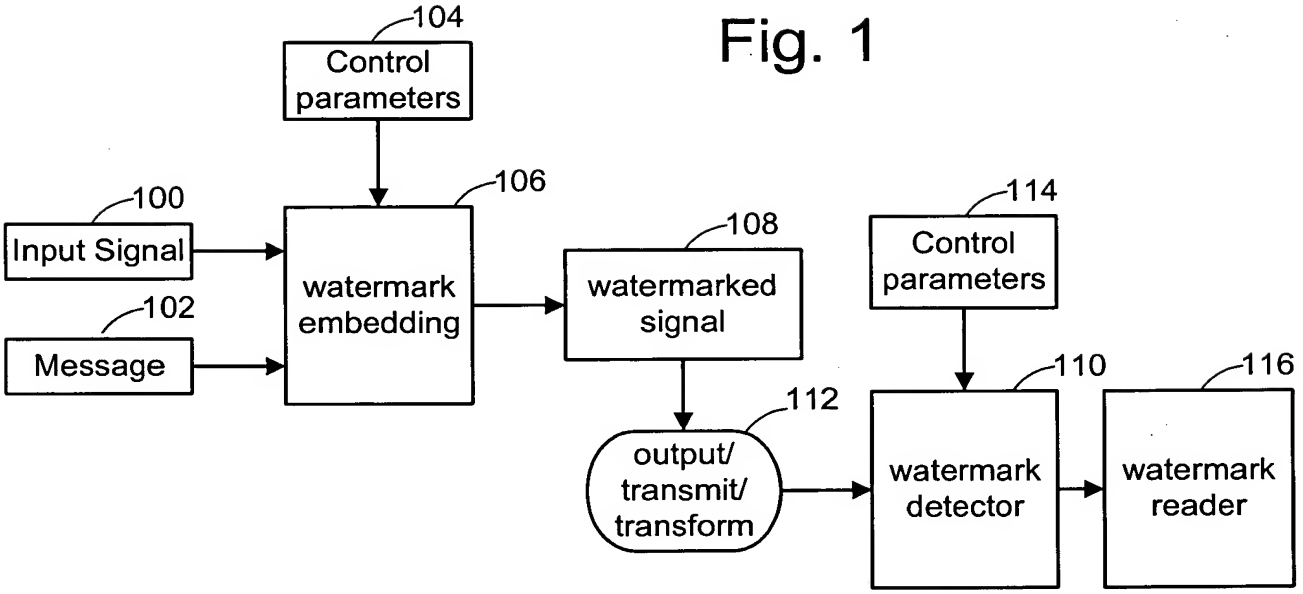
Fig. 1


104
Control parameters
100
Input Signal
102
Message
106
watermark embedding
108
watermarked signal
114
Control parameters
110
116
112
output/ transmit/ transform
watermark detector
watermark reader

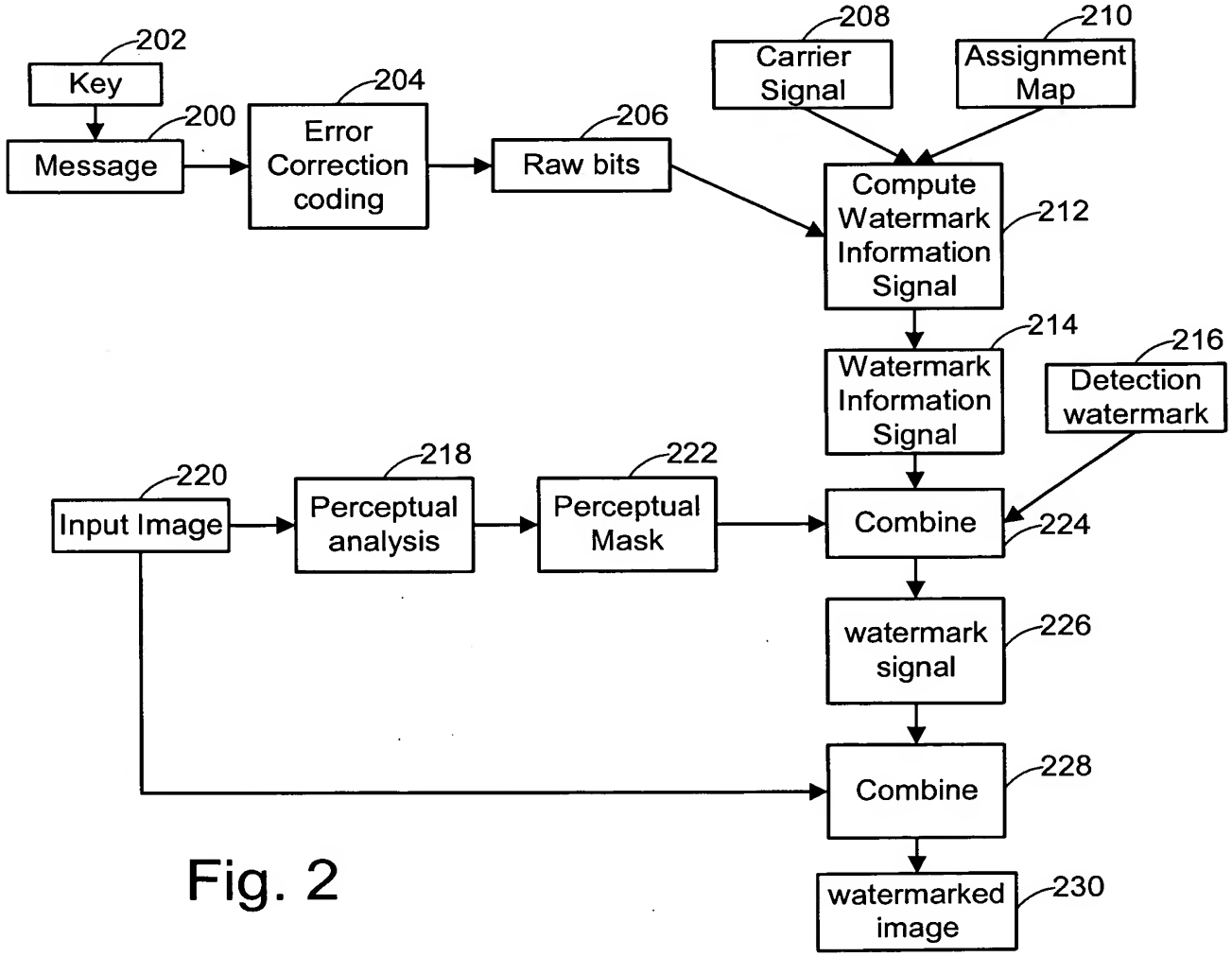

202
Key
200
Message
204
Error Correction coding
206
Raw bits
208
Carrier Signal
210
Assignment Map
Compute Watermark Information Signal
212
214
Watermark Information Signal
216
Detection watermark
220
Input Image
218
Perceptual analysis
222
Perceptual Mask
Combine
224
watermark signal
226
Combine
228
watermarked image
230

Fig. 2

Fig. 3

One Quadrant Spatial
Transform Domain

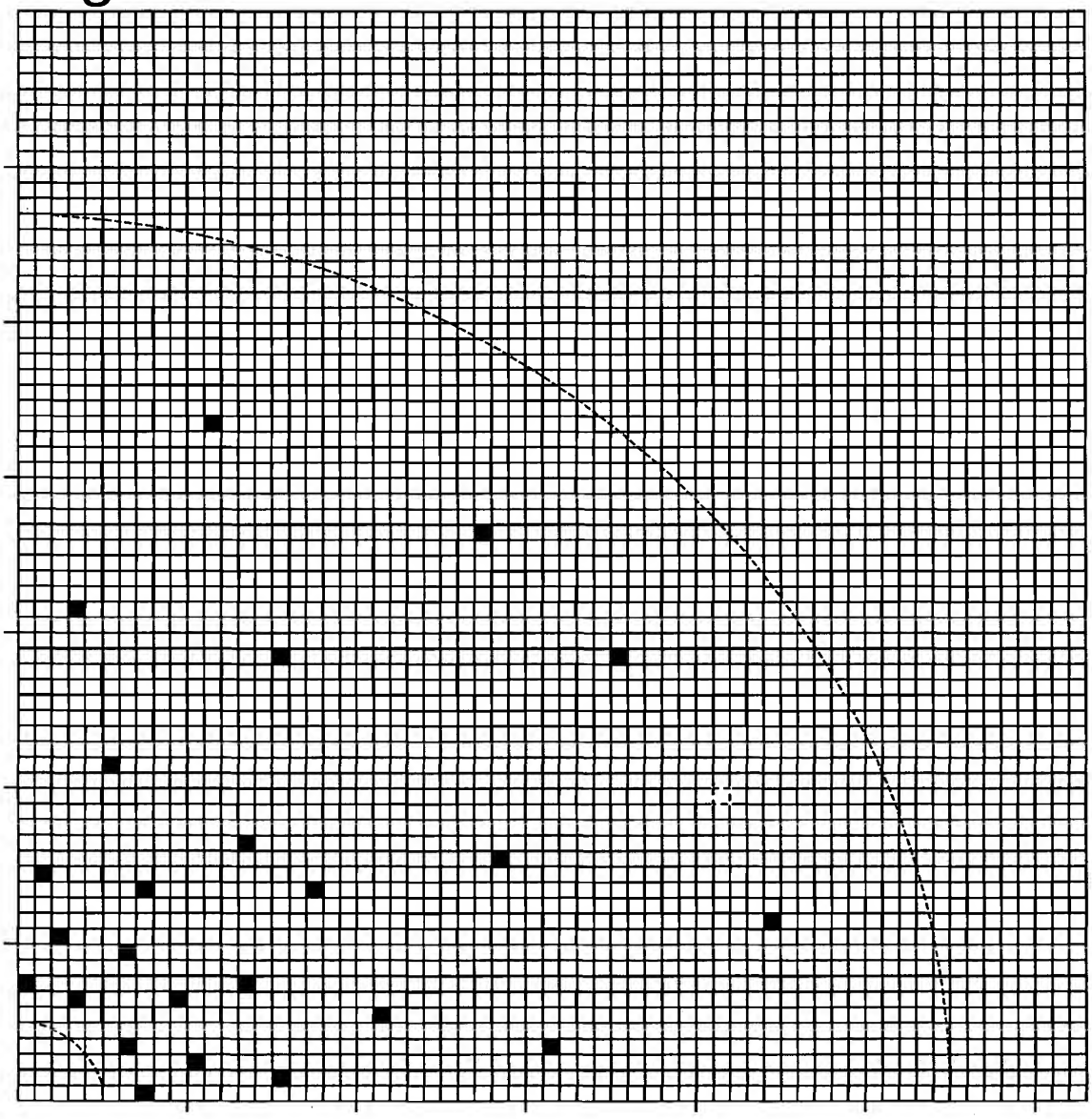


Fig. 4

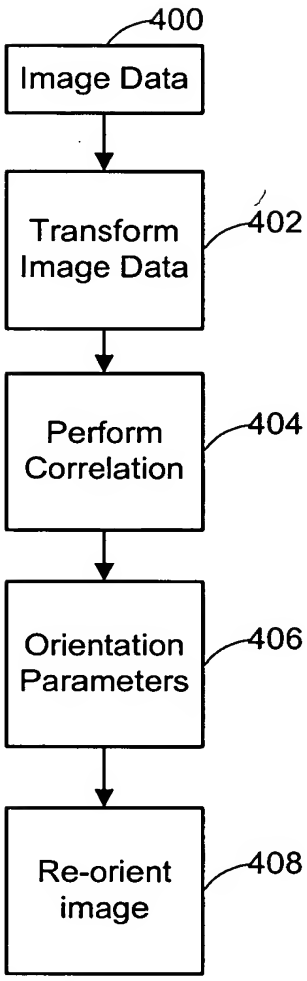
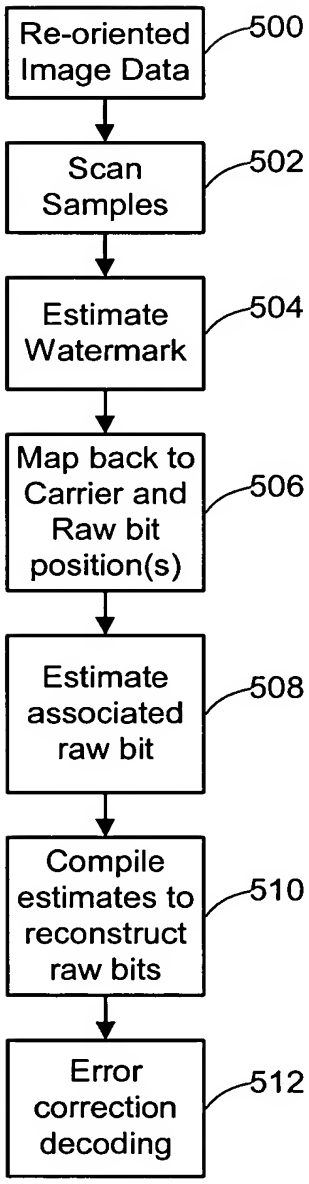

400
Image Data
Transform Image Data
402
Perform Correlation
404
Orientation Parameters
406
Re-orient image
408

Fig. 5


Re-oriented Image Data
500
Scan Samples
502
Estimate Watermark
504
Map back to Carrier and Raw bit position(s)
506
Estimate associated raw bit
508
Compile estimates to reconstruct raw bits
510
Error correction decoding
512

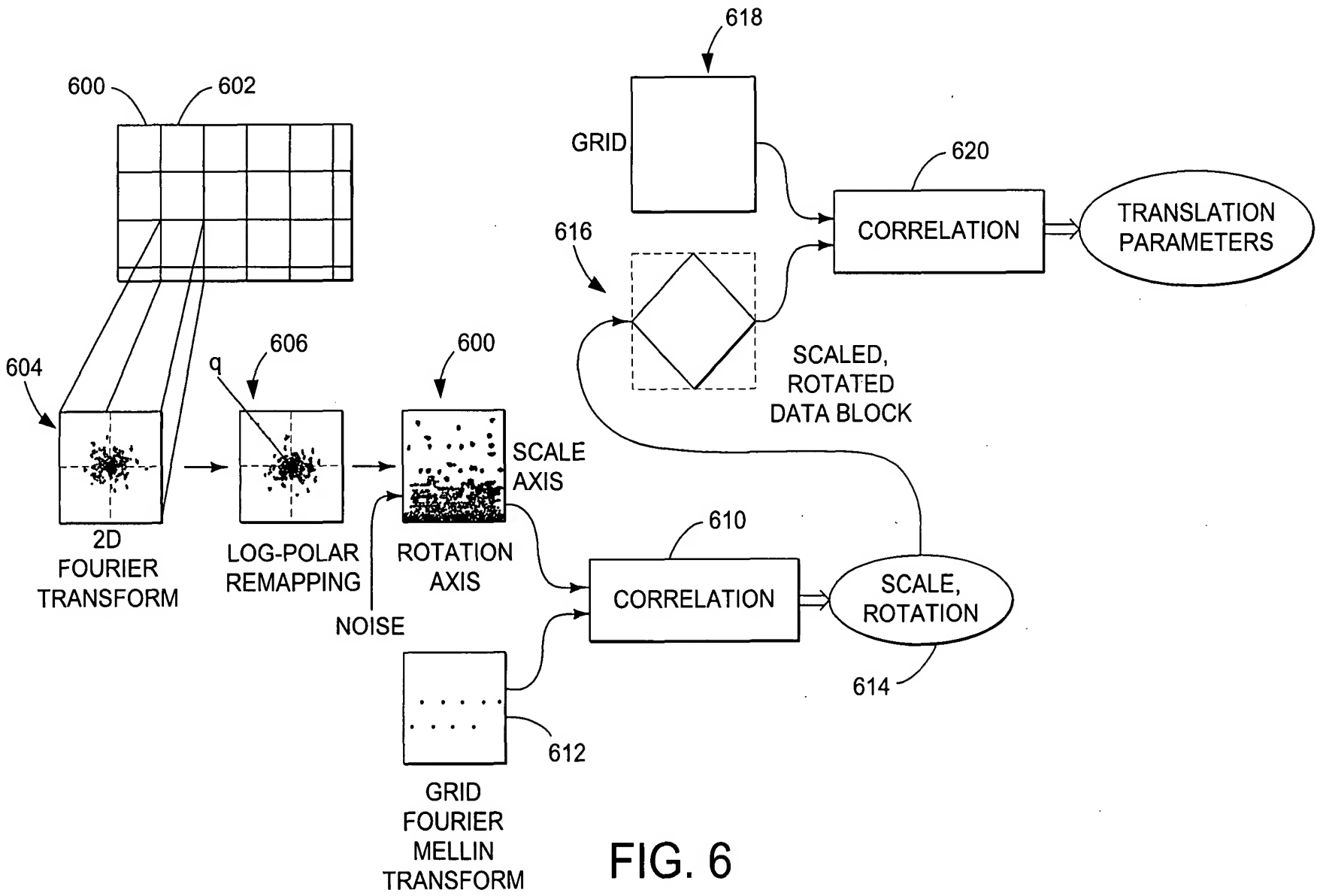
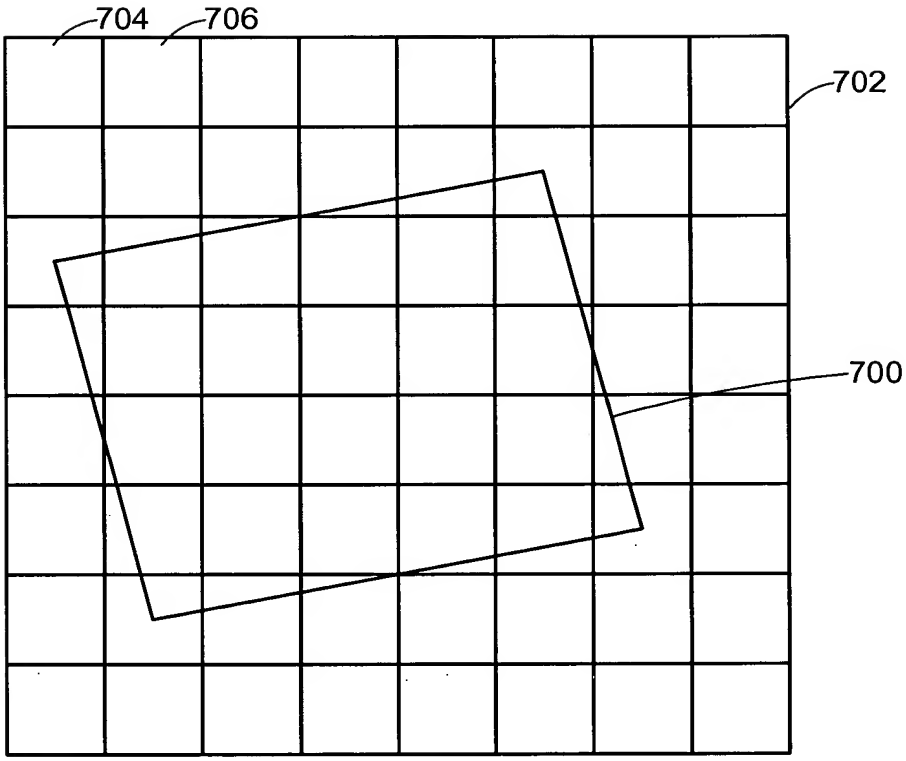

618
600
602
GRID
620
CORRELATION
TRANSLATION PARAMETERS
616
604
606
q
600
SCALED, ROTATED DATA BLOCK
SCALE AXIS
610
2D FOURIER TRANSFORM
LOG-POLAR REMAPPING
ROTATION AXIS
CORRELATION
SCALE, ROTATION
NOISE
614
612
GRID FOURIER MELLIN TRANSFORM

FIG. 6

Fig. 7



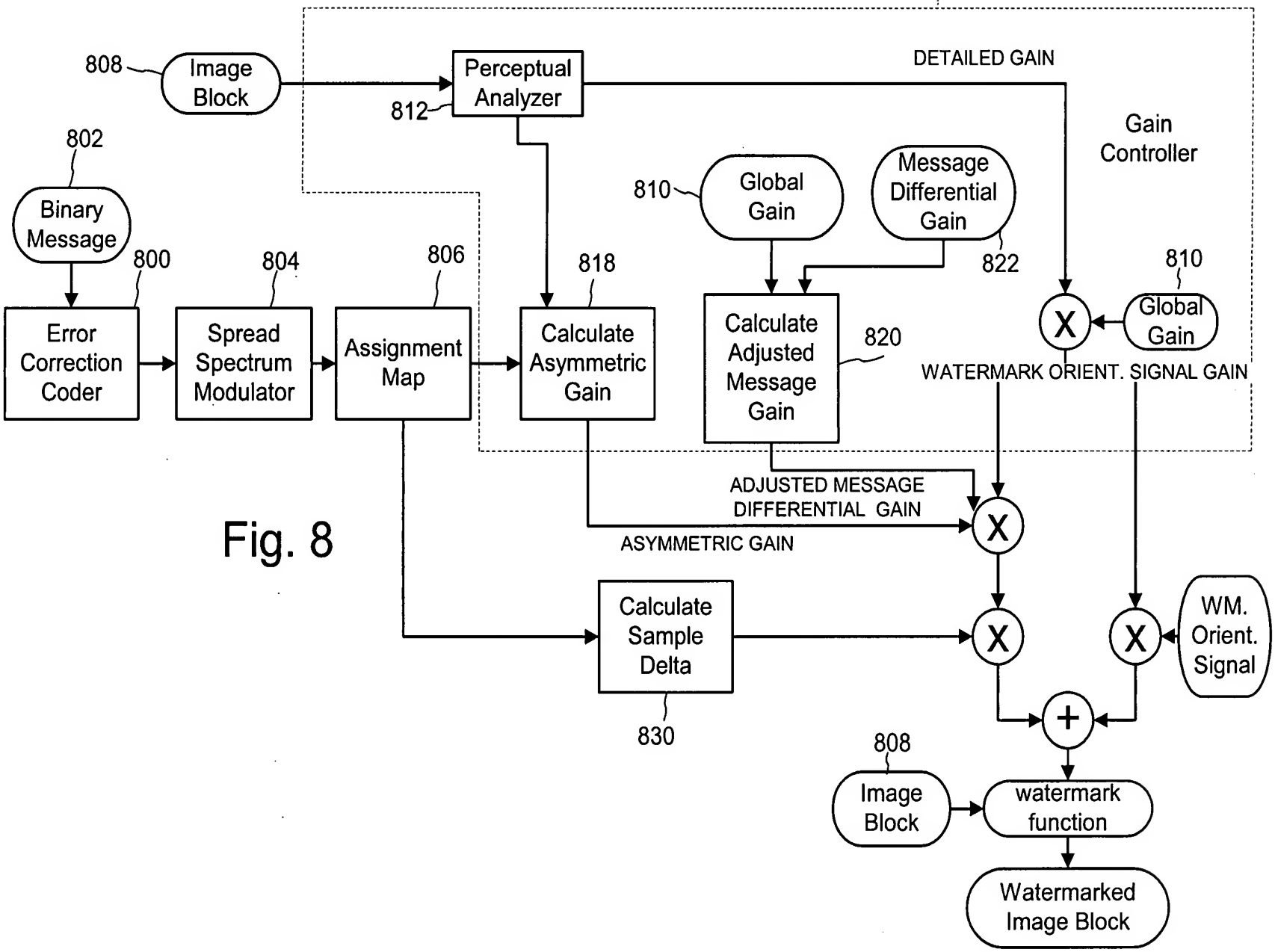
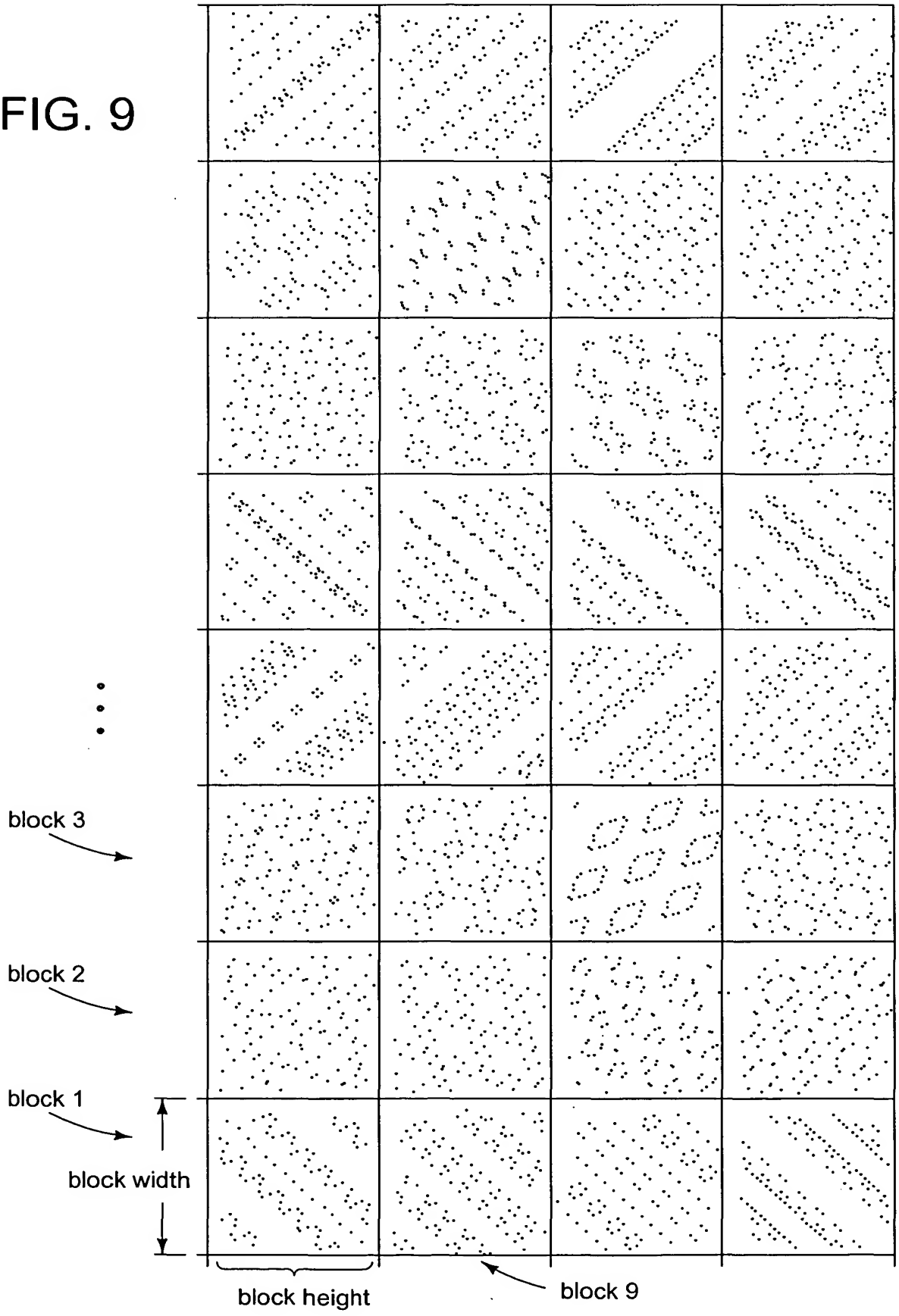

808
Image Block
Perceptual Analyzer
812
DETAILED GAIN
Gain Controller
802
Binary Message
800
Error Correction Coder
804
Spread Spectrum Modulator
806
Assignment Map
818
Calculate Asymmetric Gain
810
Global Gain
Message Differential Gain
822
Calculate Adjusted Message Gain
820
X
810
Global Gain
WATERMARK ORIENT. SIGNAL GAIN
ADJUSTED MESSAGE DIFFERENTIAL GAIN
ASYMMETRIC GAIN
X
Calculate Sample Delta
830
X
X
WM. Orient. Signal
+
808
Image Block
watermark function
Watermarked Image Block

Fig. 8

FIG. 9



MAGNITUDE OF WATERMARK ORIENTATION SIGNAL
IN FREQUENCY DOMAIN

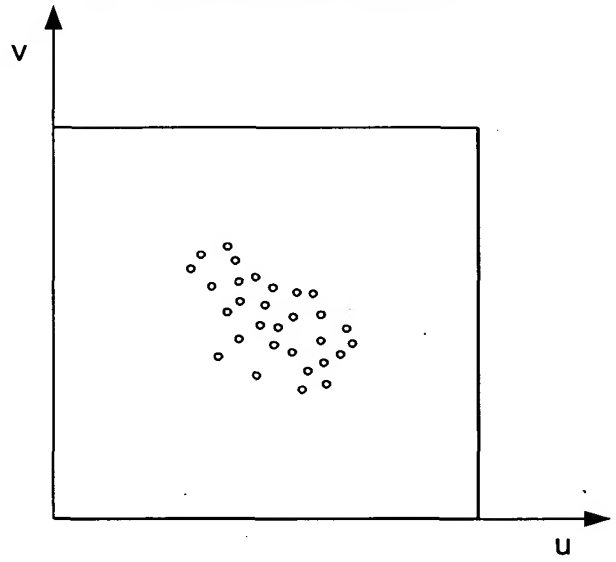


FIG. 10

REAL VALUE OF WATERMARK ORIENTATION SIGNAL
IN SPATIAL DOMAIN

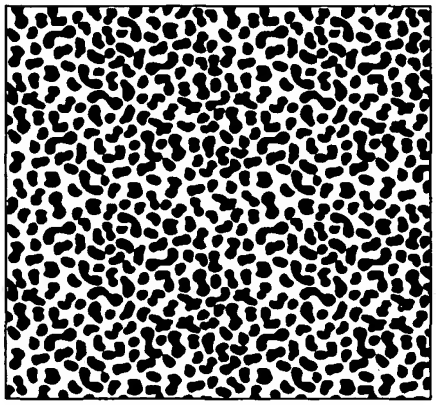


FIG. 11

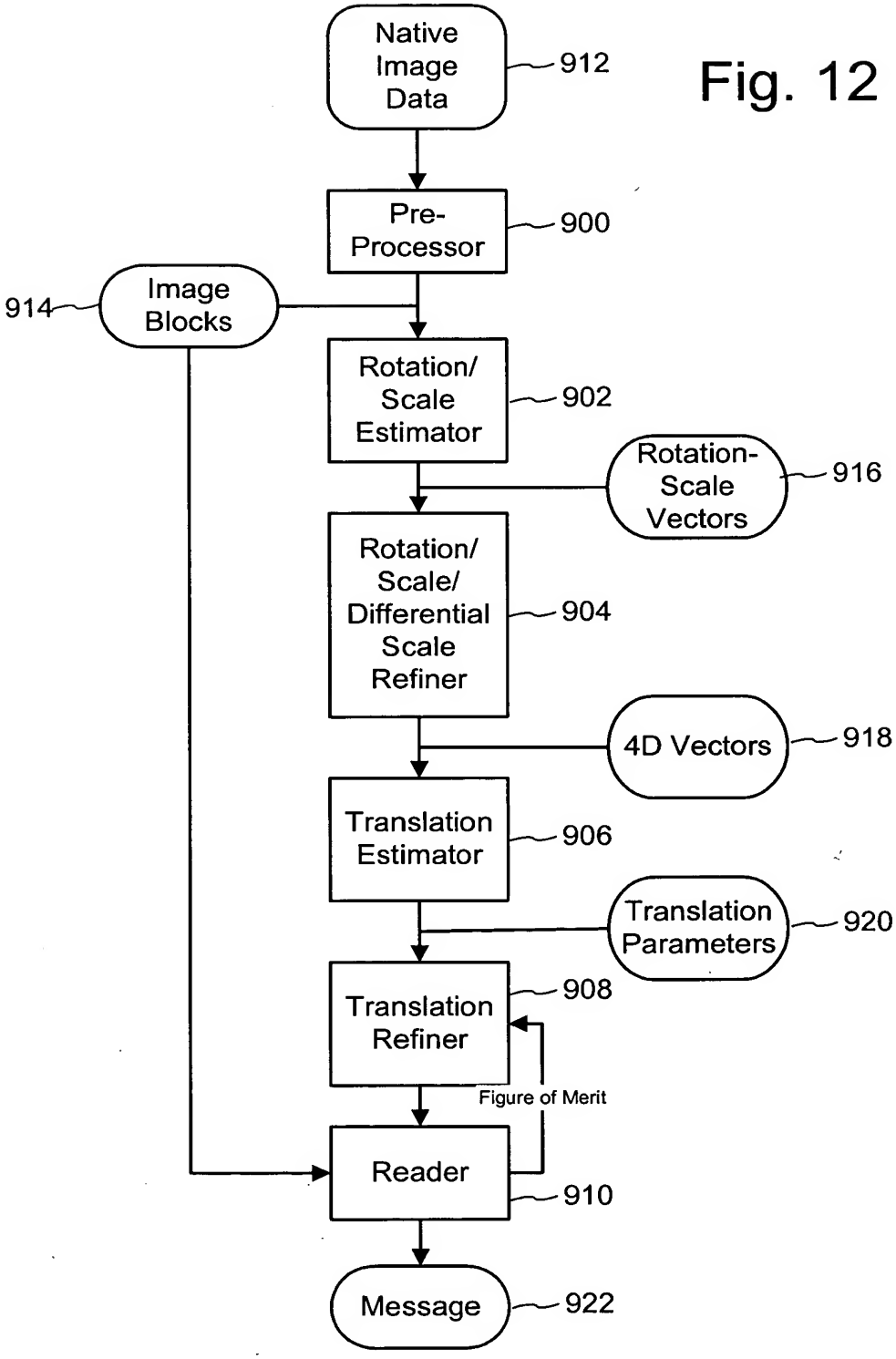

Native Image Data
912
Pre-Processor
900
914
Image Blocks
Rotation/ Scale Estimator
902
Rotation-Scale Vectors
916
Rotation/ Scale/ Differential Scale Refiner
904
4D Vectors
918
Translation Estimator
906
Translation Parameters
920
Translation Refiner
908
Figure of Merit
Reader
910
Message
922

Fig. 12

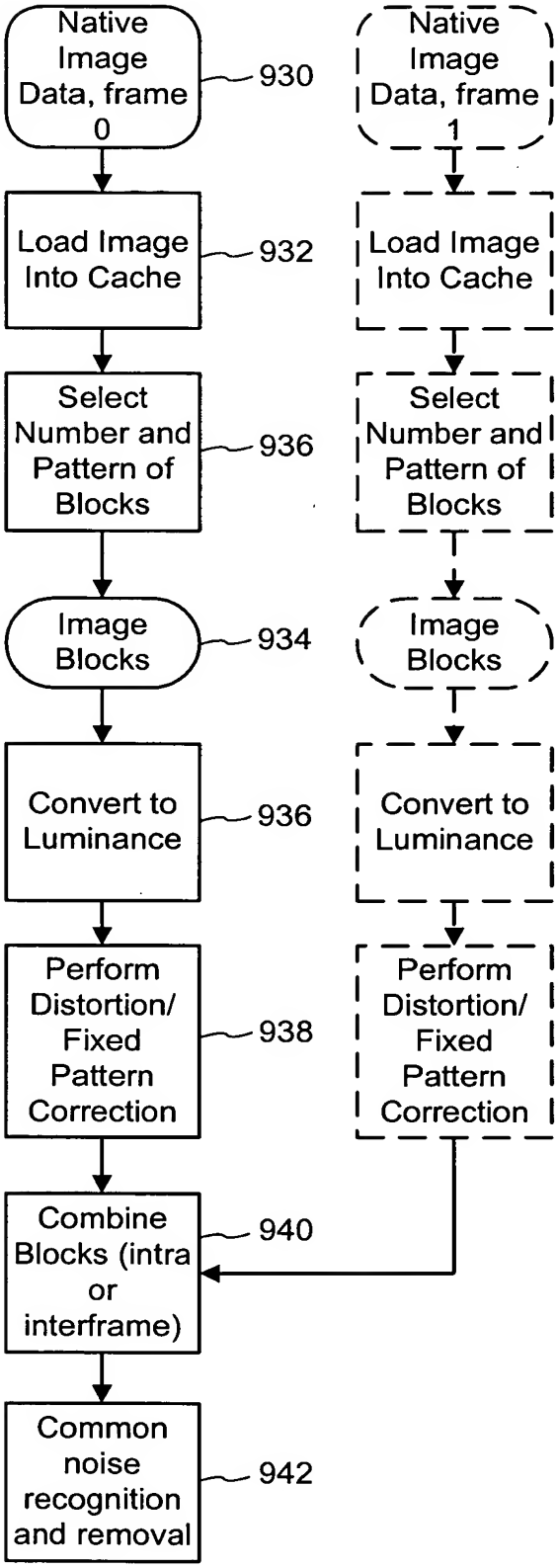

Native Image Data, frame 0
930
Native Image Data, frame 1
Load Image Into Cache
932
Load Image Into Cache
Select Number and Pattern of Blocks
936
Select Number and Pattern of Blocks
Image Blocks
934
Image Blocks
Convert to Luminance
936
Convert to Luminance
Perform Distortion/ Fixed Pattern Correction
938
Perform Distortion/ Fixed Pattern Correction
Combine Blocks (intra or interframe)
940
Common noise recognition and removal
942

Fig. 13

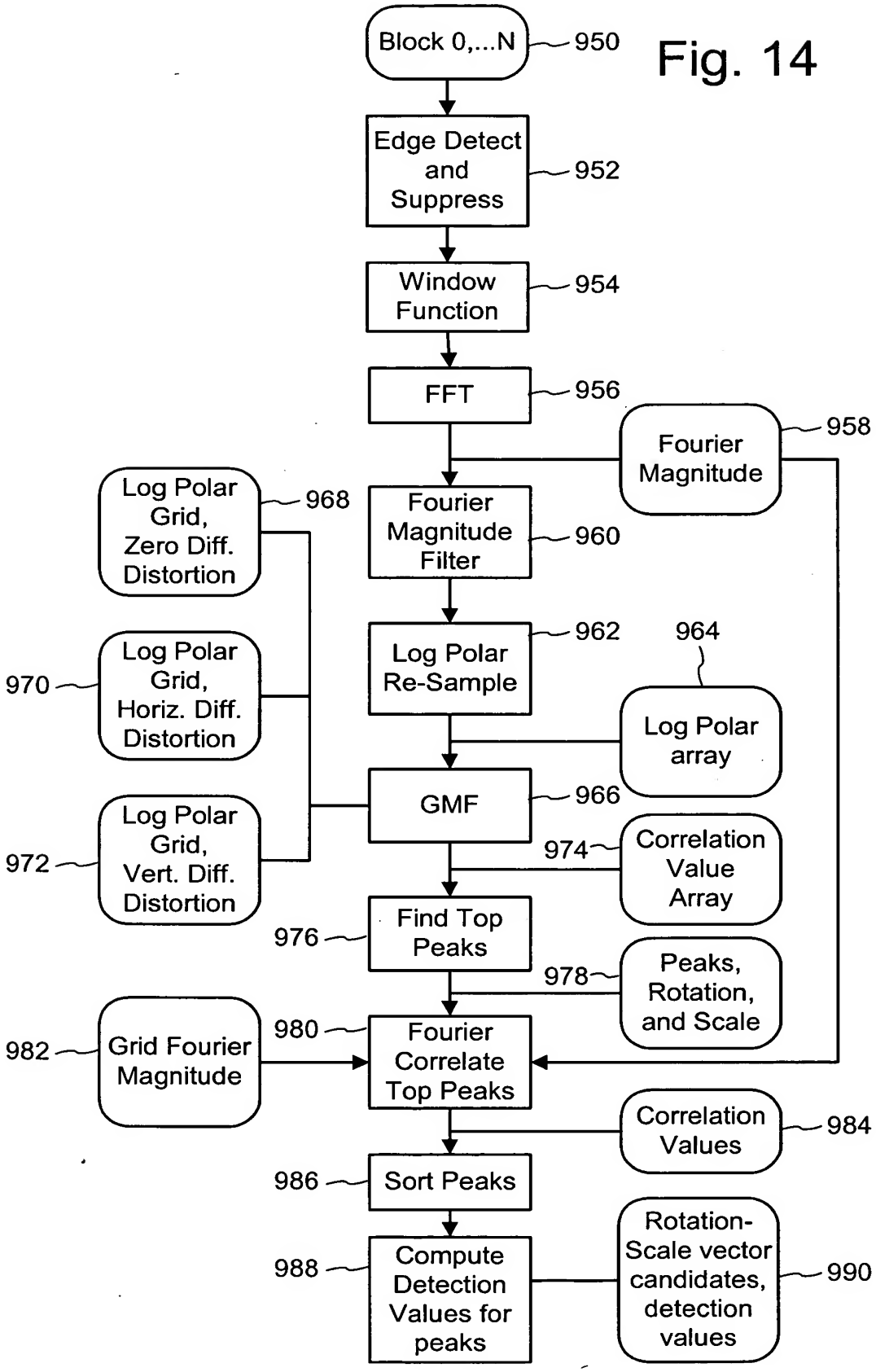

Block 0,...N
950
Edge Detect and Suppress
952
Window Function
954
FFT
956
Fourier Magnitude
958
Log Polar Grid, Zero Diff. Distortion
968
Fourier Magnitude Filter
960
Log Polar Grid, Horiz. Diff. Distortion
970
Log Polar Re-Sample
962
964
Log Polar array
Log Polar Grid, Vert. Diff. Distortion
972
GMF
966
974
Correlation Value Array
976
Find Top Peaks
978
Peaks, Rotation, and Scale
982
Grid Fourier Magnitude
980
Fourier Correlate Top Peaks
Correlation Values
984
986
Sort Peaks
988
Compute Detection Values for peaks
Rotation-Scale vector candidates, detection values
990

Fig. 14

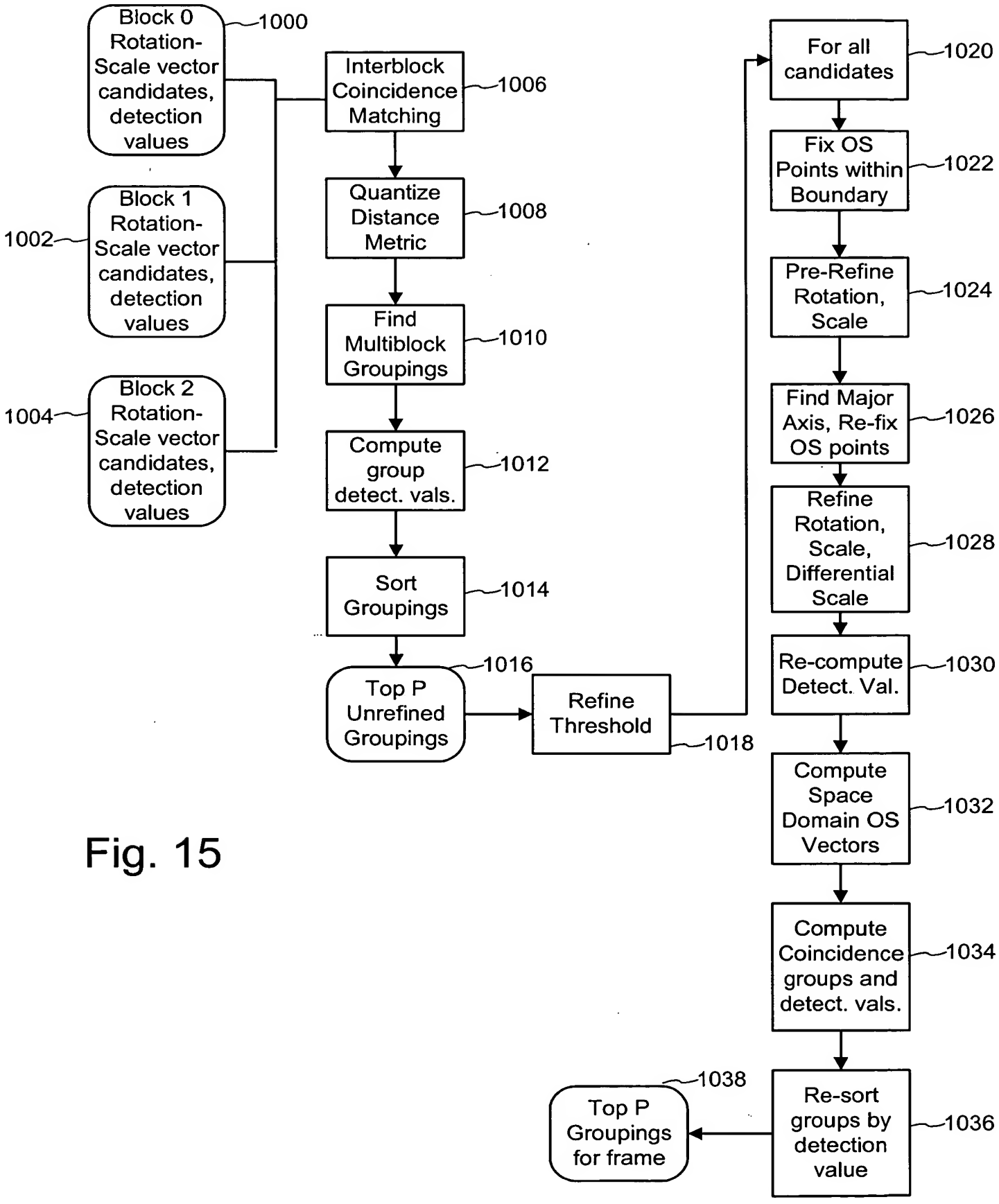
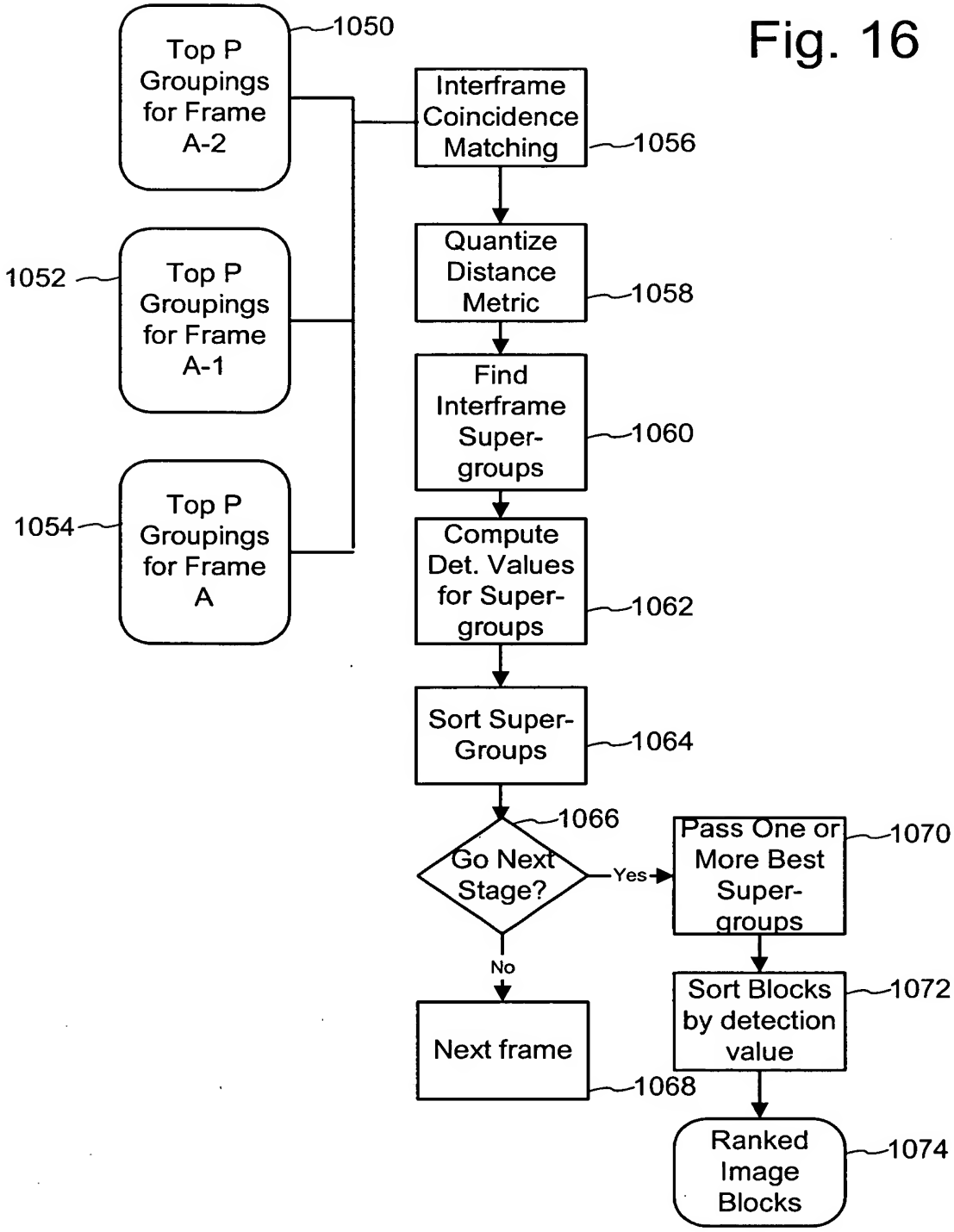

Block 0 Rotation-Scale vector candidates, detection values
1000
Block 1 Rotation-Scale vector candidates, detection values
1002
Block 2 Rotation-Scale vector candidates, detection values
1004
Interblock Coincidence Matching
1006
Quantize Distance Metric
1008
Find Multiblock Groupings
1010
Compute group detect. vals.
1012
Sort Groupings
1014
Top P Unrefined Groupings
1016
Refine Threshold
1018
For all candidates
1020
Fix OS Points within Boundary
1022
Pre-Refine Rotation, Scale
1024
Find Major Axis, Re-fix OS points
1026
Refine Rotation, Scale, Differential Scale
1028
Re-compute Detect. Val.
1030
Compute Space Domain OS Vectors
1032
Compute Coincidence groups and detect. vals.
1034
Re-sort groups by detection value
1036
Top P Groupings for frame
1038

Fig. 15

Fig. 16


Top P Groupings for Frame A-2
1050
Top P Groupings for Frame A-1
1052
Top P Groupings for Frame A
1054
Interframe Coincidence Matching
1056
Quantize Distance Metric
1058
Find Interframe Super-groups
1060
Compute Det. Values for Super-groups
1062
Sort Super-Groups
1064
Go Next Stage?
1066
Yes
No
Pass One or More Best Super-groups
1070
Sort Blocks by detection value
1072
Next frame
1068
Ranked Image Blocks
1074

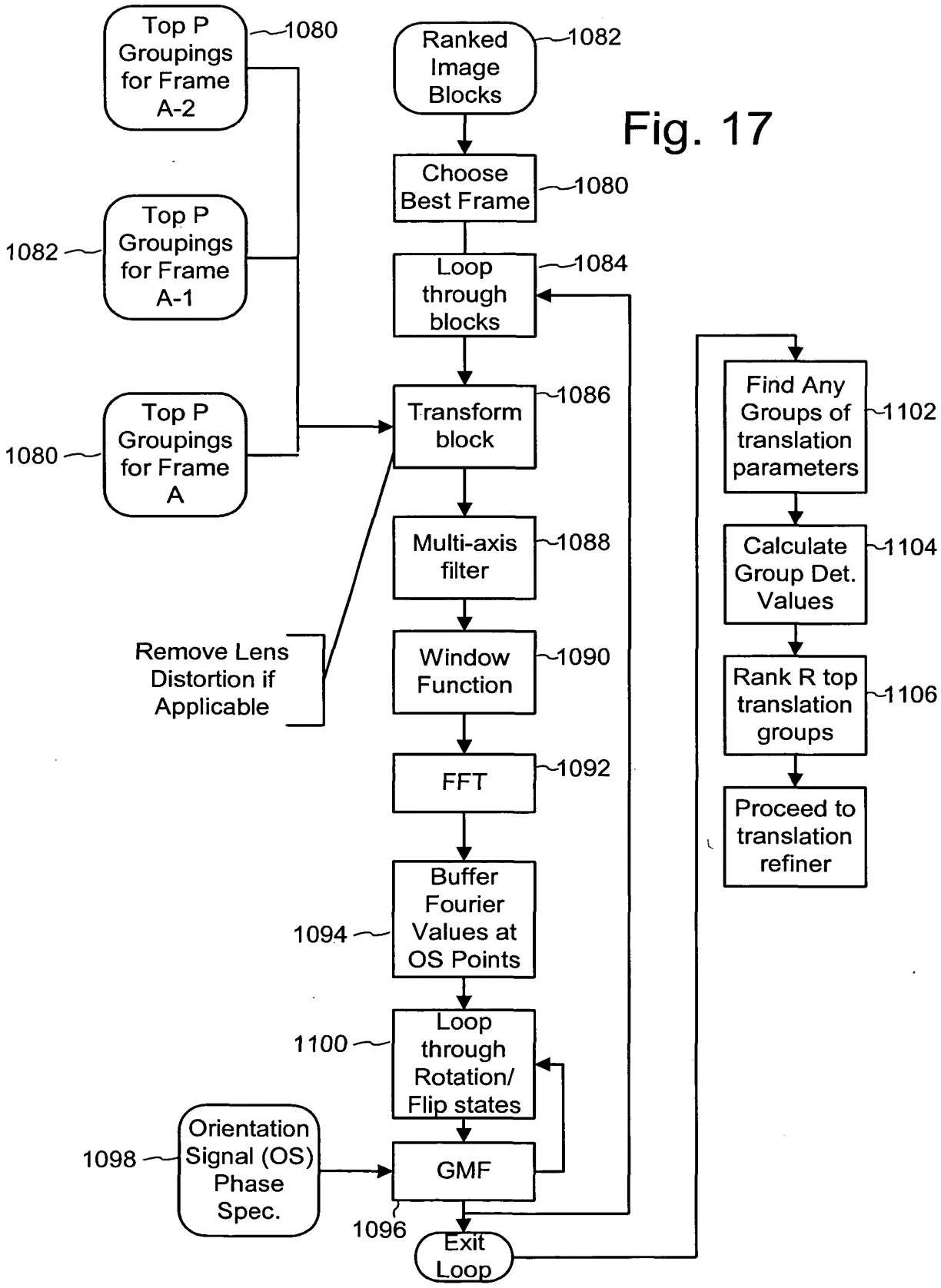

Top P Groupings for Frame A-2
1080
Top P Groupings for Frame A-1
1082
Top P Groupings for Frame A
1080
Ranked Image Blocks
1082
Choose Best Frame
1080
Loop through blocks
1084
Transform block
1086
Multi-axis filter
1088
Window Function
1090
FFT
1092
Buffer Fourier Values at OS Points
1094
Loop through Rotation/ Flip states
1100
GMF
Orientation Signal (OS) Phase Spec.
1098
1096
Exit Loop
Remove Lens Distortion if Applicable
Find Any Groups of translation parameters
1102
Calculate Group Det. Values
1104
Rank R top translation groups
1106
Proceed to translation refiner

Fig. 17

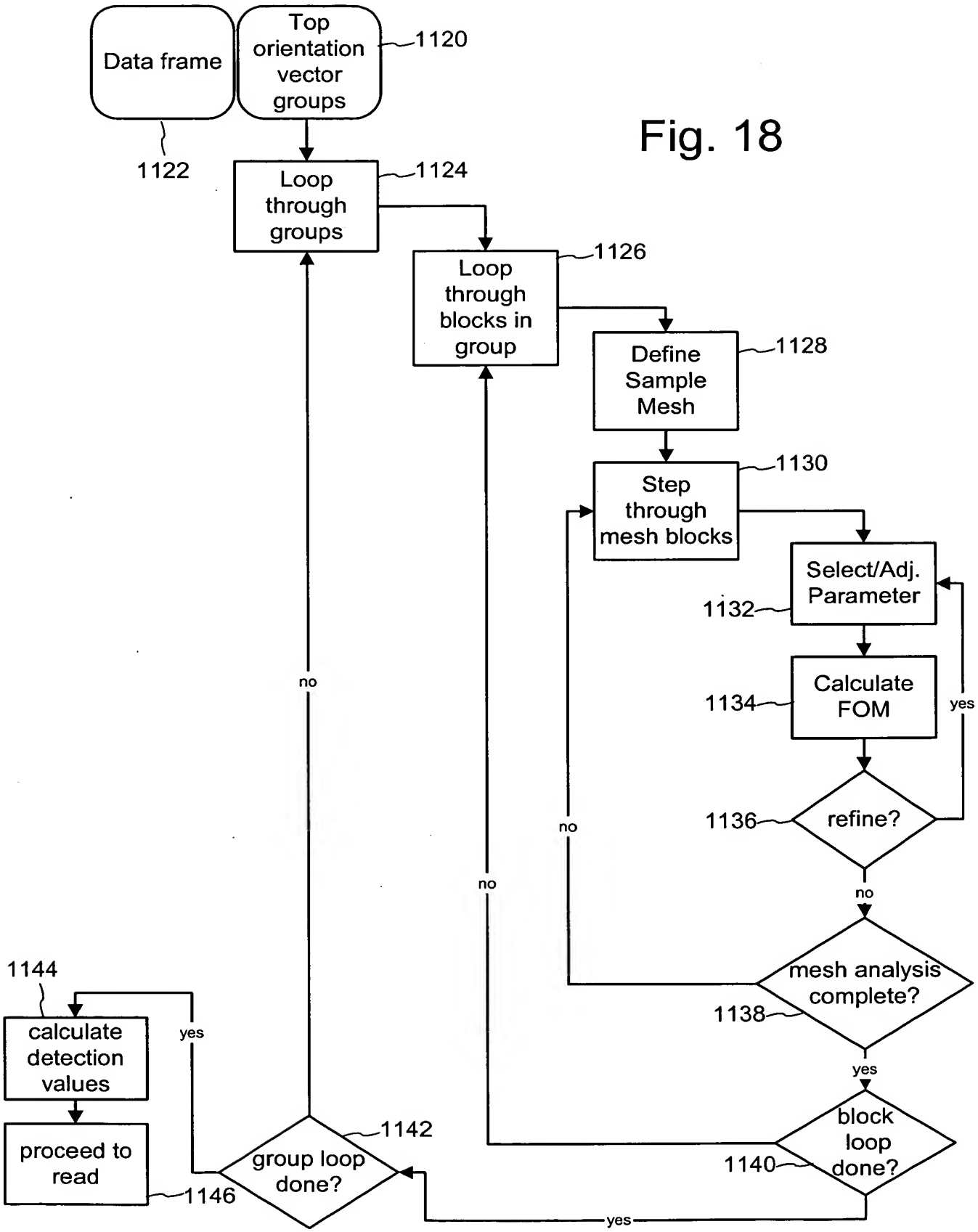

Data frame
Top orientation vector groups
1120
1122
Loop through groups
1124
Loop through blocks in group
1126
Define Sample Mesh
1128
Step through mesh blocks
1130
Select/Adj. Parameter
1132
Calculate FOM
1134
refine?
1136
mesh analysis complete?
1138
block loop done?
1140
group loop done?
1142
calculate detection values
1144
proceed to read
1146
no
yes
no
no
yes
no
yes
yes

Fig. 18

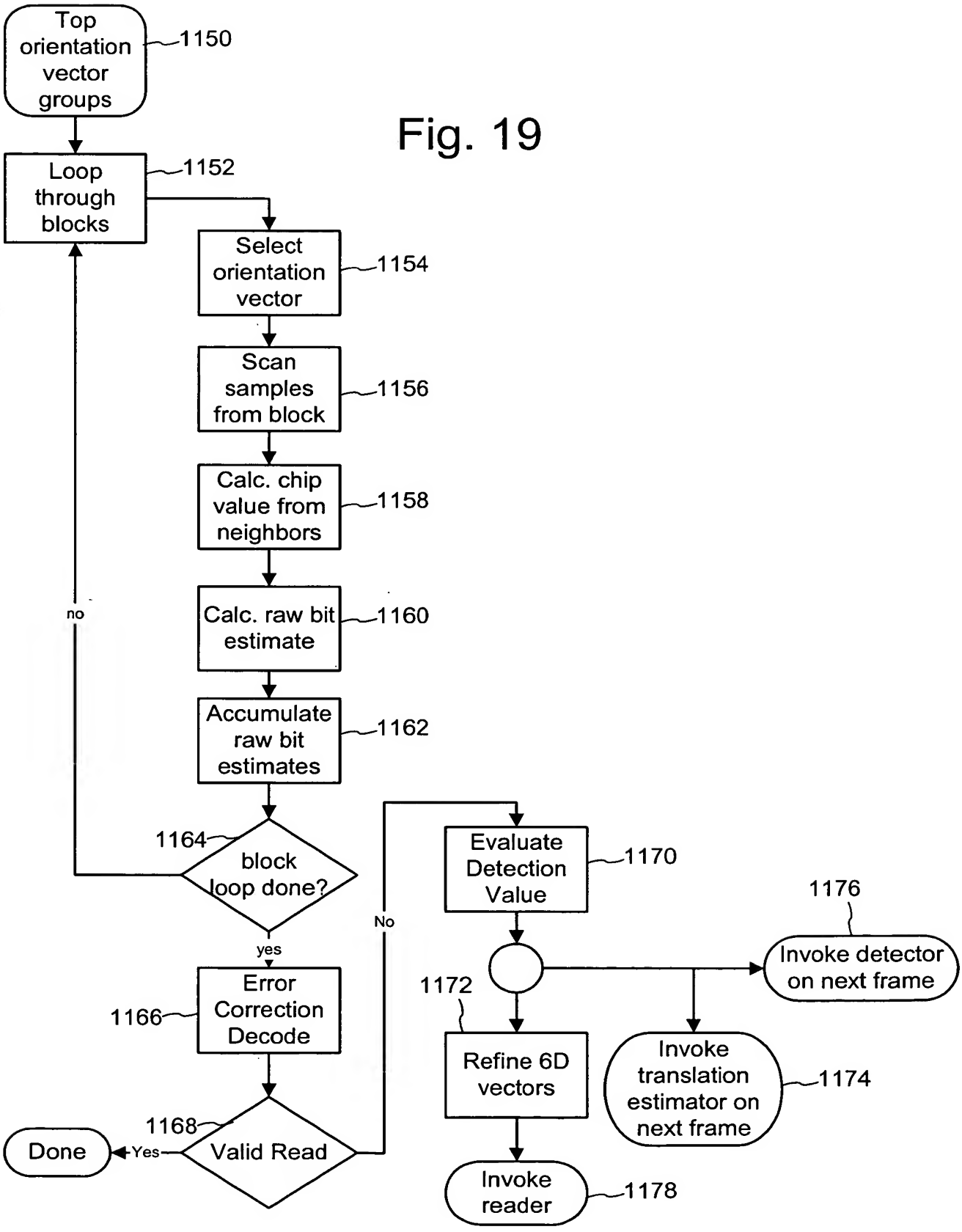
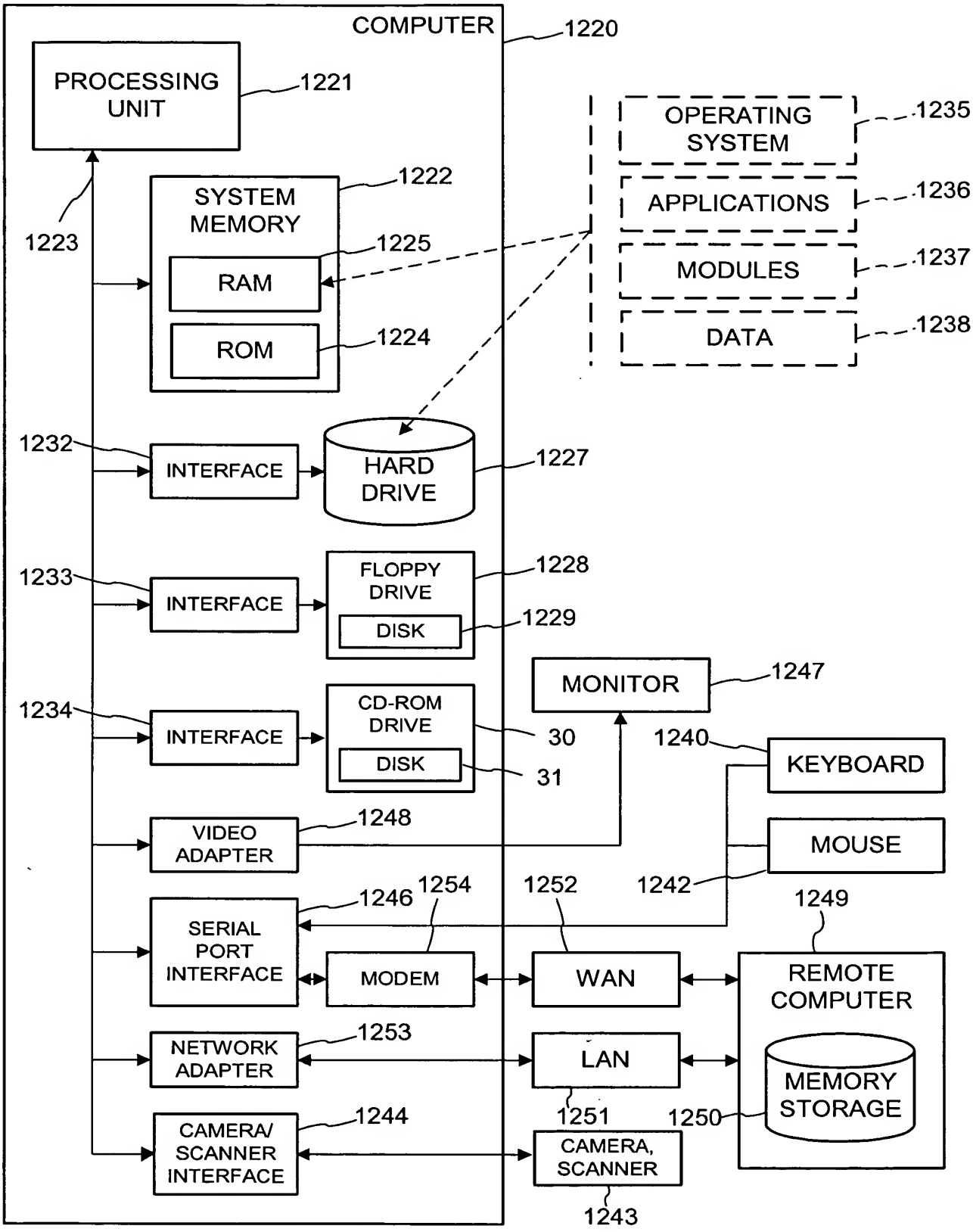

Top orientation vector groups
1150
Loop through blocks
1152
Select orientation vector
1154
Scan samples from block
1156
Calc. chip value from neighbors
1158
Calc. raw bit estimate
1160
Accumulate raw bit estimates
1162
1164
block loop done?
no
yes
Error Correction Decode
1166
1168
Valid Read
Yes
Done
No
Evaluate Detection Value
1170
1172
Refine 6D vectors
Invoke reader
1178
Invoke translation estimator on next frame
1174
1176
Invoke detector on next frame

Fig. 19

FIG. 20


COMPUTER
1220
PROCESSING UNIT
1221
1223
SYSTEM MEMORY
1222
RAM
1225
ROM
1224
OPERATING SYSTEM
1235
APPLICATIONS
1236
MODULES
1237
DATA
1238
1232
INTERFACE
HARD DRIVE
1227
1233
INTERFACE
FLOPPY DRIVE
1228
DISK
1229
1234
INTERFACE
CD-ROM DRIVE
30
DISK
31
MONITOR
1247
1240
KEYBOARD
MOUSE
1242
VIDEO ADAPTER
1248
1246
1254
1252
1249
SERIAL PORT INTERFACE
MODEM
WAN
REMOTE COMPUTER
MEMORY STORAGE
1250
NETWORK ADAPTER
1253
LAN
1251
CAMERA/ SCANNER INTERFACE
1244
CAMERA, SCANNER
1243

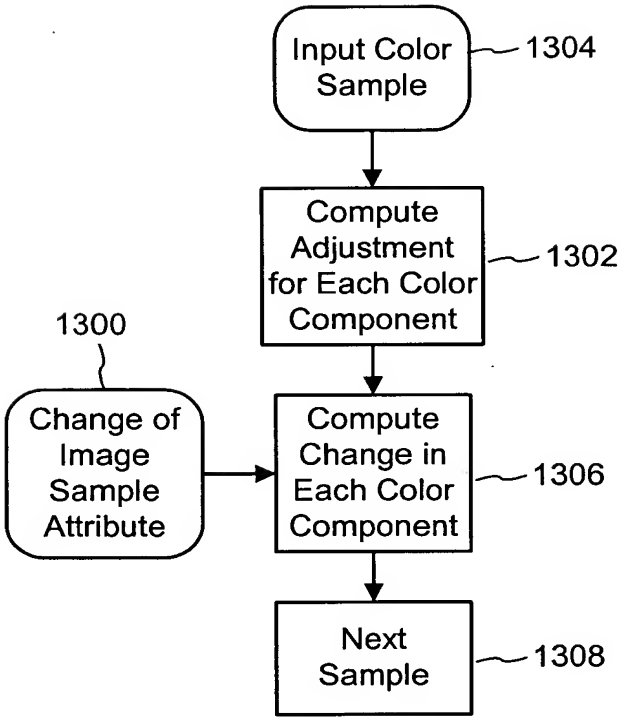

Input Color Sample
1304
Compute Adjustment for Each Color Component
1302
1300
Change of Image Sample Attribute
Compute Change in Each Color Component
1306
Next Sample
1308

Fig. 21

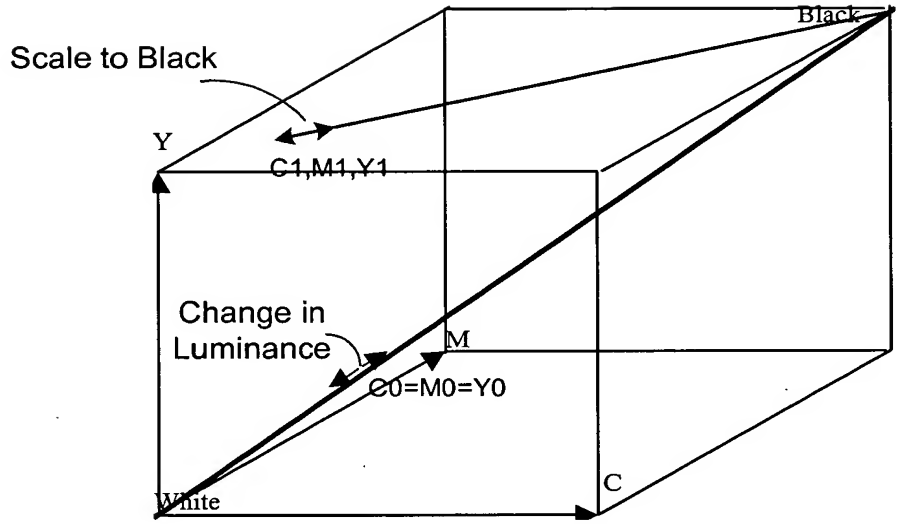

Scale to Black
Black
Y
C1,M1,Y1
Change in
Luminance
M
C0=M0=Y0
C
White

Fig. 22

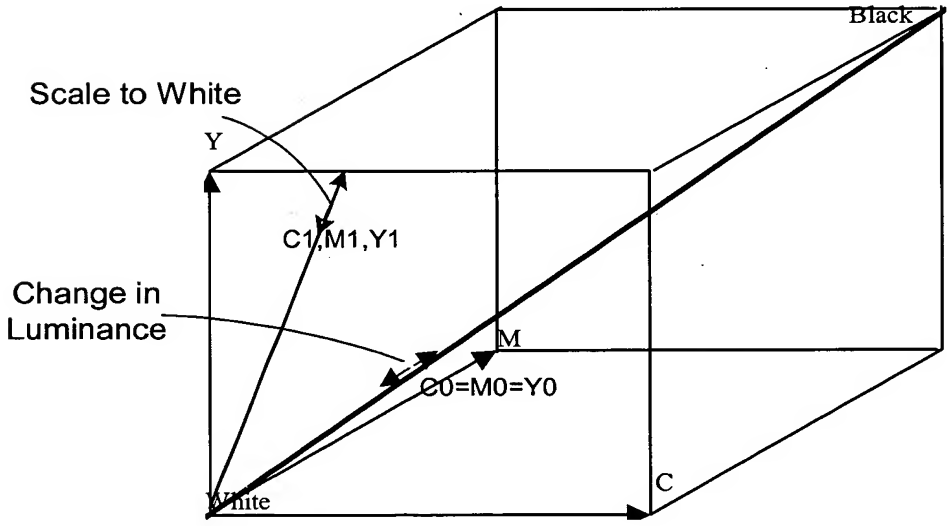

Scale to White
Black
Y
C1,M1,Y1
Change in
Luminance
M
C0=M0=Y0
C
White

Fig. 23

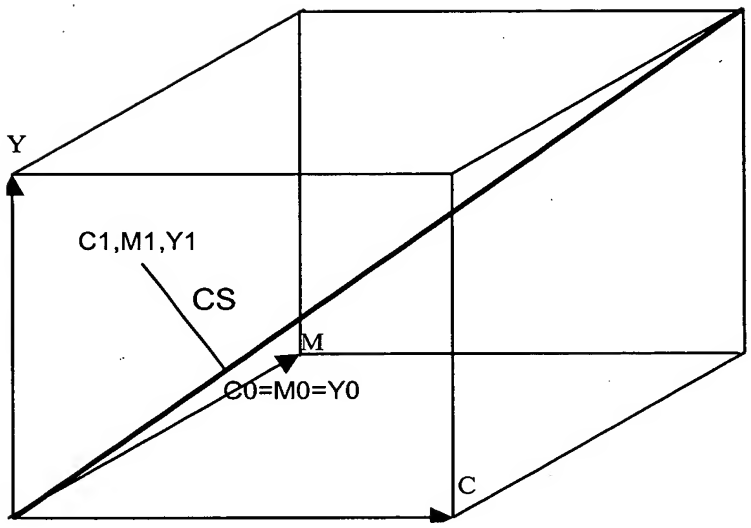

Y
C1,M1,Y1
CS
M
C0=M0=Y0
C

Fig. 24

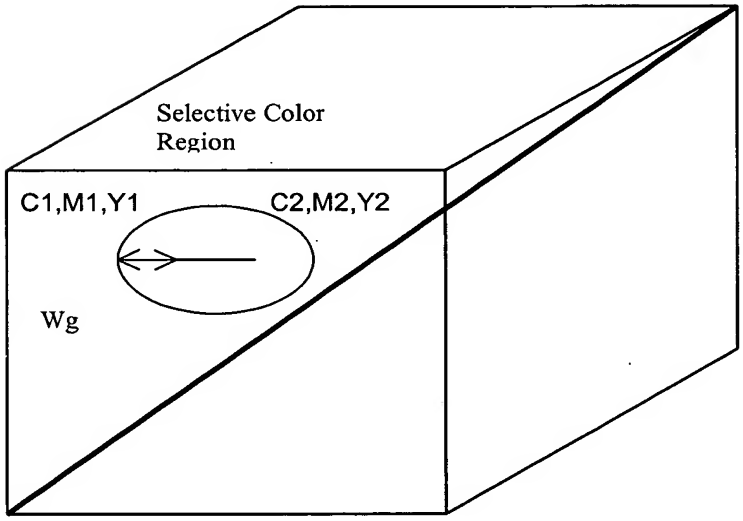

Selective Color
Region
C1,M1,Y1
C2,M2,Y2
Wg

Fig. 25